

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
7 November 2002 (07.11.2002)

PCT

(10) International Publication Number
WO 02/088170 A2

(51) International Patent Classification⁷: C07K

(21) International Application Number: PCT/US02/11950

(22) International Filing Date: 17 April 2002 (17.04.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

60/286,782	26 April 2001 (26.04.2001)	US
60/293,020	17 May 2001 (17.05.2001)	US
60/301,091	26 June 2001 (26.06.2001)	US
60/367,002	22 March 2002 (22.03.2002)	US

(71) Applicant (for all designated States except US): BIO-GEN, INC. [US/US]; 14 Cambridge Center, Cambridge, MA 02142 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): SANI-COLA-NADEL, Michele [US/US]; 4 Maple Road,

Winchester, MA 02142 (US). WILLIAMS, Kevin [GB/US]; 7 Malden Street, Natick, MA 01760 (US). SCHIFFER, Susan [US/US]; 6 Moreland Avenue, Lexington, MA 02421 (US). RAYHORN, Paul [US/US]; 48 Mirimichi Road, Foxborough, MA 02035 (US).

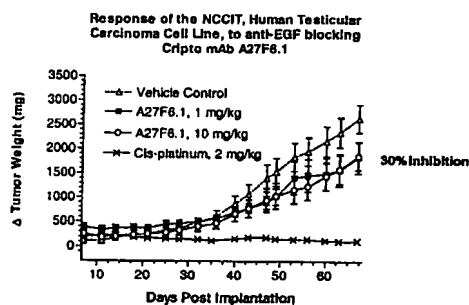
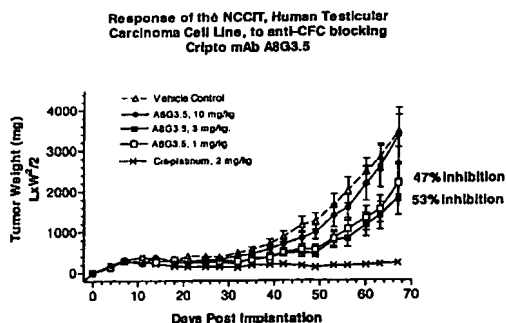
(74) Agent: COX, Niki, D.; Biogen, Inc., 14 Cambridge Center, Cambridge, MA 02142 (US).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

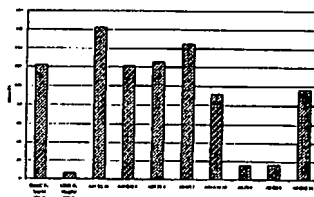
(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: CRIPTO BLOCKING ANTIBODIES AND USES THEREOF



FACS: 293/ALK4 cells binding CR-Fc



(57) Abstract: The invention provides Cripto blocking antibodies, or biologically functional fragments thereof, and uses thereof. Antibodies which bind Cripto and modulate Cripto signaling are provided. Antibodies which bind Cripto and block the interaction between Cripto and ALK4 are provided. Antibodies which bind Cripto and modulate tumor growth are also provided. Antibodies which bind Cripto, modulate signaling, and modulate tumor growth are also provided. Antibodies which bind Cripto, block the interaction between Cripto and ALK4 and modulate tumor growth are provided. The invention also provides methods of using these antibodies in therapeutic, diagnostic, and research applications.

**Published:**

— without international search report and to be republished upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

CRIPTO BLOCKING ANTIBODIES AND USES THEREOF

Related Applications

This is a continuation of U.S.S.N. 60/367,002, filed March 22, 2002, which is a continuation-in-part of U.S.S.N. 60/301,091, filed June 26, 2001, which is a
5 continuation-in-part of U.S.S.N. 60/293,020, filed on May 17, 2001, which is a continuation-in-part of U.S.S.N. 60/286,782, filed on April 26, 2001. The entire disclosure of each of the aforesaid patent applications are incorporated herein by reference.

Technical Field of the Invention

10 The present invention relates generally to the fields of genetics and cellular and molecular biology. More particularly, the invention relates to antibodies which bind to and modulate the signaling of Cripto, kits comprising such antibodies, and methods which use the antibodies.

Background of the Invention

15 Cripto is a cell surface protein of 188 amino acid residues serendipitously isolated in a cDNA screen of a human embryonic carcinoma library (Ciccodicola et al., 1989, EMBO J., vol. 8, no. 7, pp. 1987-1991). The Cripto protein has at least two notable domains: a cysteine-rich domain, and a domain first characterized as similar to the domain found in the epidermal growth factor (EGF) family. Cripto was originally
20 classified as a member of the EGF family (Ciccodicola et al., supra); however, subsequent analysis showed that Cripto did not bind any of the known EGF receptors and its EGF-like domain was actually divergent from the EGF family (Bianco et al., 1999, J. Biol. Chem., 274:8624-8629).

The Cripto signaling pathway has remained elusive despite continued
25 investigation, with the literature supporting activation of several different pathways, including a MAP kinase pathway (DeSantis et al., 1997, Cell Growth Differ., 8:1257-

1266; Kannan et al., 1997, J. Biol. Chem., 272:3330-3335), the TGF- β pathway
(Gritsman et al., 1999, Development, 127:921-932; Schier et al., 2000, Nature,
403:385-389), possible interactions with the Wnt pathway (Salomon et al., Endocr
Relat Cancer. 2000 Dec;7(4):199-226; and cross talk with the EGF pathway (Bianco et
5 al., 1999, J. Biol. Chem., 274:8624-8629).

U.S. Patent 5,256,643 and two divisional applications related thereto (U.S.
Patents 5,654,140 and 5,792,616), disclose a human Cripto gene, Cripto protein, and
antibodies to Cripto.

U.S. Patent 5,264,557 and three divisional applications related thereto (U.S.
10 Patents 5,620,866, 5,650,285, and 5,854,399), disclose a human Cripto-related gene
and protein. Also disclosed are antibodies which bind to the Cripto-related protein but
do not cross react by binding to the Cripto protein itself.

Cripto protein overexpression is associated with many tumor types (including
but not limited to breast, testicular, colon, lung, ovary, bladder, uterine, cervical,
15 pancreatic, and stomach), as demonstrated by immunostaining of human tissue with
rabbit polyclonal antibodies raised against small cripto peptides. Panico et al., 1996,
Int. J. Cancer, 65: 51-56; Byrne et al., 1998, J Pathology, 185:108-111; De Angelis et
al., 1999, Int J Oncology, 14:437-440. The art is therefore in need of means of
controlling, restricting, and/or preventing such overexpression, modulating Cripto
20 signaling, and modulating the consequences of Cripto expression (i.e., promotion
and/or maintenance of cell transformation).

Summary of the Invention

The present invention provides novel antibodies which specifically bind to
Cripto, and methods of making and using such antibodies. The invention also provides
25 antibodies which bind to Cripto, and modulate Cripto signaling or protein interaction,
e.g., an antibody which binds to Cripto such that the signal resulting from a protein

interaction with Cripto is modulated downward. The invention also provides antibodies which bind to Cripto and block the interaction between Cripto and ALK4. The invention also provides antibodies which bind to Cripto and modulate tumor growth. The invention also provides antibodies which bind to Cripto, modulate Cripto signaling and modulate tumor growth. The invention also provides antibodies which bind to Cripto, block the interaction between Cripto and ALK4 and modulate tumor growth

In one aspect of the invention, the antibody of the present invention specifically binds to an epitope selected from the group of epitopes to which antibodies A6C12.11, A6F8.6 (ATCC ACCESSION NO. PTA-3318), A7H1.19, A8F1.30, A8G3.5 (ATCC ACCESSION NO. PTA-3317), A8H3.1 (ATCC ACCESSION NO. PTA-3315), A8H3.2, A19A10.30, A10B2.18 (ATCC ACCESSION NO. PTA-3311), A27F6.1 (ATCC ACCESSION NO. PTA-3310), A40G12.8 (ATCC ACCESSION NO. PTA-3316), A2D3.23, A7A10.29, A9G9.9, A15C12.10, A15E4.14, A17A2.16, A17C12.28, A17G12.1 (ATCC ACCESSION NO. PTA-3314), A17H6.1, A18B3.11 (ATCC ACCESSION NO. PTA-3312), A19E2.7, B3F6.17 (ATCC ACCESSION NO. PTA-3319), B6G7.10 (ATCC ACCESSION NO. PTA-3313), B11H8.4 bind.

In another aspect of the invention, the antibody of the present invention specifically binds to an epitope in the ligand/receptor binding domain of Cripto. Cripto can be selected from CR-1 (SEQ ID NO:1) or CR-3 (SEQ ID NO:2). In a more particular embodiment, antibodies that specifically binds to the epitope in the ligand/receptor binding domain include for example A6C12.11, A6F8.6 (ATCC ACCESSION NO. PTA-3318), A8G3.5 (ATCC ACCESSION NO. PTA-3317), A19A10.30, A8H3.1 (ATCC ACCESSION NO. PTA-3315), A27F6.1 (ATCC ACCESSION NO. PTA-3310), A40G12.8 (ATCC ACCESSION NO. PTA-3316),

A17G12.1 (ATCC ACCESSION NO. PTA-3314), A18B3.11 (ATCC ACCESSION NO. PTA-3312) and B6G7.10 (ATCC ACCESSION NO. PTA-3313).

In one embodiment the epitope to which the antibodies of the present invention bind is in an EGF-like domain. Antibodies that specifically bind to the epitope in the EGF-like domain include but are not limited to A40G12.8 (ATCC ACCESSION NO. PTA-3316), A8H3.1 (ATCC ACCESSION NO. PTA-3315), A27F6.1 (ATCC ACCESSION NO. PTA-3310), B6G7.10 (ATCC ACCESSION NO. PTA-3313), A17G12.1 (ATCC ACCESSION NO. PTA-3314) and A18B3.11 (ATCC ACCESSION NO. PTA-3312).

In another embodiment the epitope to which the antibodies of the present invention bind is in a cys-rich domain. Antibodies that specifically bind to the epitope in the cys-rich domain include but are not limited to A19A10.30, A8G3.5 (ATCC ACCESSION NO. PTA-3317), A6F8.6 (ATCC ACCESSION NO. PTA-3318) and A6C12.11.

In another embodiment the epitope to which the antibodies of the present invention bind is in the domain spanning amino acid residues 46-62 of Cripto. Antibodies that specifically bind to the epitope in the domain spanning amino acid residues 46-62 of Cripto include but are not limited to A10B2.18 (ATCC ACCESSION NO. PTA-3311), B3F6.17 (ATCC ACCESSION NO. PTA-3319) and A17A2.16.

The present inventions also contemplate antibodies which binds specifically to Cripto and are capable of modulating Cripto signaling. Antibodies that bind specifically to Cripto and are capable of modulating Cripto signaling, include but are not limited to, A40G12.8 (ATCC ACCESSION NO. PTA-3316), A8H3.1 (ATCC ACCESSION NO. PTA-3315), A27F6.1 (ATCC ACCESSION NO. PTA-3310), and A6C12.11. In one embodiment the antibodies of the present invention which binds specifically to Cripto

and are capable of modulating Cripto signaling bind to an epitope in an EGF-like domain or a cys-rich domain of Cripto.

The present inventions also contemplate antibodies which binds specifically to Cripto and blocks the interaction between Cripto and ALK4. Antibodies that bind specifically to Cripto and are capable of blocking the interaction between Cripto and ALK4, include but are not limited to, A8G3.5 (ATCC ACCESSION NO. PTA-3317), A6F8.6 (ATCC ACCESSION NO. PTA-3318) and A6C12.11. In one embodiment the antibodies of the present invention which binds specifically to Cripto and are capable of blocking the interaction between Cripto and ALK4 bind to an epitope in an EGF-like domain or a cys-rich domain of Cripto.

In another aspect, the present invention contemplates antibodies which bind specifically to Cripto and are capable of modulating tumor growth. Antibodies that specifically bind to Cripto and are capable of modulating tumor growth include but are not limited to, A27F6.1 (ATCC ACCESSION NO. PTA-3310), B6G7.10 (ATCC ACCESSION NO. PTA-3313) and A8G3.5 (ATCC ACCESSION NO. PTA-3317).

In one embodiment the antibodies of the present invention which bind specifically to Cripto and are capable of modulating tumor growth bind to an epitope in an EGF-like domain or a cys-rich domain of Cripto.

In yet another aspect, the present invention contemplates antibodies which bind specifically to Cripto, which are capable of modulating Cripto signaling, and which are capable of modulating tumor growth. Antibodies that specifically bind to Cripto, which are capable of modulating Cripto signaling, and which are capable of modulating tumor growth, include but are not limited to A27F6.1 (ATCC ACCESSION NO. PTA-3310).

In one embodiment the antibodies of the present invention which bind specifically to Cripto, which are capable of modulating Cripto signaling, and which are

capable of modulating tumor growth bind to an epitope in an EGF-like domain or a cys-rich domain of Cripto.

In yet another aspect, the present invention comtemplates antibodies which bind specifically to Cripto, which are capable of blocking the interaction between Cripto and
5 ALK4, and which are capable of modulating tumor growth. Antibodies that specifically bind to Cripto, which are capable of blocking the interaction between Cripto and ALK4, and which are capable of modulating tumor growth, include but are not limited to A8G3.5 (ATCC ACCESSION NO. PTA-3317).

In another embodiment, the present invention provides an antibody produced by
10 a hybridoma selected from the group consisting of A6F8.6 (ATCC Accession No. PTA-3318), A8G3.5 (ATCC Accession No. PTA-3317), A8H3.1 (ATCC Accession No. PTA-3315), A10B2.18 (ATCC Accession No. PTA-3311), A27F6.1 (ATCC Accession No. PTA-3310), A40G12.8 (ATCC Accession No. PTA-3316), A17G12.1 (ATCC Accession No. PTA-3314), A18B3.11 (ATCC Accession No. PTA-3312), B3F6.17
15 (ATCC Accession No. PTA-3319), and B6G7.10 (ATCC Accession No. PTA-3313).

The antibodies of the present invention include but are not limited to monoclonal, polyclonal, humanized, chimeric and human antibodies.

The present invention also provides for a composition for administration to a subject having a tumor that expresses Cripto comprising at least one of the antibodies
20 described above. In a more particular embodiment the subject is human. The composition may include a pharmaceutically acceptable excipient. The antibodies described above can be conjugated to a chemotherapeutic agent or be provided in combination with a nonconjugated chemotherapeutic.

Contemplated in another aspect of the invention are methods of modulating growth of tumor cells *in vitro* in a sample comprising the step of adding to the sample the compositions described above.

Also contemplated are methods of modulating growth of tumor cells *in vivo* in a subject comprising the step of administering to the subject an effective amount of the compositions described above. In a particular embodiment the subject is human.

Another aspect of the invention are methods of treating subjects having a tumor that over-expresses Cripto comprising administering to the subject the compositions described above in an effective amount. Compositions for administration may include pharmaceutically acceptable excipients, antibodies conjugated to chemotherapeutic agents and antibodies administered in combination with nonconjugated chemotherapeutic agents

The methods of the present invention are particularly useful in modulating growth of tumor cells and/or treating a subject (i.e. a human) having a tumor where the tumor cell is selected from breast, testicular, colon, lung, ovary, bladder, uterine, cervical, pancreatic, and stomach tumor cells.

In yet another embodiment, the present invention contemplates methods of determining whether a tissue expresses Cripto, comprising the step of analyzing tissue from the subject in an immunoassay using any of the antibodies described above. Also contemplated are methods of determining whether a cell line overexpresses Cripto, comprising the step of analyzing the cell line in an immunoassay using any of the antibodies described above.

These and other aspects of the invention are set forth in greater detail below in the Detailed Description of the Invention.

Detailed Description of the Invention

Antibodies that specifically bind to Cripto and their uses for modulating Cripto signaling or protein interaction, and/or block the interaction between Cripto and ALK4, and/or modulate the growth of tumor cells have been discovered. Various classes of antibodies that specifically bind to Cripto have been discovered, including, for

5 example, antibodies that specifically bind to an epitope in the ligand/receptor binding domain of either a native Cripto protein or a denatured form of Cripto; antibodies that bind an EGF-like domain, a cys-rich domain, or a peptide (e.g., from about 3 to about 20 amino acids) from the region comprising amino acid residues 46 to 150; antibodies that bind Cripto and modulate Cripto signalling; antibodies that bind Cripto and

10 modulate tumor cell growth; and antibodies that bind to Cripto, modulate Cripto signaling, and modulate tumor cell growth. These antibodies are selected using conventional in vitro assays for selecting antibodies which bind the ligand/receptor binding domain, modulate Cripto signaling, or modulate tumor cell growth.

The methods of this invention are useful in the therapy of malignant or benign

15 tumors of mammals where the growth rate of the tumor (which is an abnormal rate for the normal tissue) is at least partially dependent upon Cripto. Abnormal growth rate is a rate of growth which is in excess of that required for normal homeostasis and is in excess of that for normal tissues of the same origin.

Definitions

20 Various definitions are made throughout this document. Most words have the meaning that would be attributed to those words by one skilled in the art. Words specifically defined either below or elsewhere in this document have the meaning provided in the context of the present invention as a whole and as are typically understood by those skilled in the art.

As used herein, the term "region" means a physically contiguous portion of the primary structure of a biomolecule. In the case of proteins, a region is defined by a contiguous portion of the amino acid sequence of that protein.

As used herein, the term "domain" refers to a structural part of a biomolecule that contributes to a known or suspected function of the biomolecule. Domains may be co-extensive with regions or portions thereof; domains may also incorporate a portion of a biomolecule that is distinct from a particular region, in addition to all or part of that region. Examples of protein domains include, but are not limited to the extracellular domain (spans from about residue 31 to about residue 188 of Cripto, including Cripto, CR-1 (SEQ ID NO: 1) and CR-3 (SEQ ID NO:2)) and transmembrane domain (spans from about residue 169 to about residue 188 of Cripto, including Cripto, CR-1 (SEQ ID NO: 1) and CR-3 (SEQ ID NO:2)). A ligand/receptor binding domain of the Cripto protein spans from about residue 75 to about residue 150 of Cripto, including Cripto, CR-1 (SEQ ID NO: 1) and CR-3 (SEQ ID NO:2) and includes the EGF-like domain of Cripto, which spans, for example, from about residue 75 to about residue 112 of Cripto, including Cripto, CR-1 (SEQ ID NO: 1) and CR-3 (SEQ ID NO:2) and the cysteine-rich domain of Cripto, which spans, for example, from about residue 114 to about residue 150 of Cripto, including Cripto, CR-1 (SEQ ID NO: 1) and CR-3 (SEQ ID NO:2). For example, many monoclonal antibodies of the present invention have been identified as binding to the EGF-like or cys-rich domains. Additionally monoclonal antibody A10B2.18 (ATCC ACCESSION NO. PTA-3311), B3F6.17 (ATCC ACCESSION NO. PTA-3319) and A17A2.16 have been identified as binding to an epitope formed in a domain in the region spanning amino acid residues 46-62, upstream of the EGF-like domain. See Example 3 below. An epitope in the ligand/receptor

binding domain is an epitope, whether formed in the conformational native Cripto protein, or the denatured Cripto protein, to which antibodies may bind.

As used herein, the term "antibody" is meant to refer to complete, intact antibodies, and Fab, Fab', F(ab)2, and other fragments thereof. Complete, intact
5 antibodies include, but are not limited to, monoclonal antibodies such as murine monoclonal antibodies, polyclonal antibodies, chimeric antibodies, human antibodies, and humanized antibodies. Various forms of antibodies may be produced using standard recombinant DNA techniques (Winter and Milstein, Nature 349: 293-99, 1991). For example, "chimeric" antibodies may be constructed, in which the antigen
10 binding domain from an animal antibody is linked to a human constant domain (an antibody derived initially from a nonhuman mammal in which recombinant DNA technology has been used to replace all or part of the hinge and constant regions of the heavy chain and/or the constant region of the light chain, with corresponding regions from a human immunoglobulin light chain or heavy chain) (see, e.g., Cabilly et al.,
15 United States patent 4,816,567; Morrison et al., Proc. Natl. Acad. Sci. 81: 6851-55, 1984). Chimeric antibodies reduce the immunogenic responses elicited by animal antibodies when used in human clinical treatments.

In addition, recombinant "humanized" antibodies may be synthesized. Humanized antibodies are antibodies initially derived from a nonhuman mammal in
20 which recombinant DNA technology has been used to substitute some or all of the amino acids not required for antigen binding with amino acids from corresponding regions of a human immunoglobulin light or heavy chain. That is, they are chimeras comprising mostly human immunoglobulin sequences into which the regions responsible for specific antigen-binding have been inserted (see, e.g., PCT patent
25 application WO 94/04679). Animals are immunized with the desired antigen, the

corresponding antibodies are isolated and the portion of the variable region sequences responsible for specific antigen binding are removed. The animal-derived antigen binding regions are then cloned into the appropriate position of the human antibody genes in which the antigen binding regions have been deleted. Humanized antibodies
5 minimize the use of heterologous (inter-species) sequences in antibodies for use in human therapies, and are less likely to elicit unwanted immune responses. Primatized antibodies can be produced similarly.

Another embodiment of the invention includes the use of human antibodies, which can be produced in nonhuman animals, such as transgenic animals harboring one
10 or more human immunoglobulin transgenes. Such animals may be used as a source for splenocytes for producing hybridomas, as is described in US Patent 5,569,825.

Antibody fragments and univalent antibodies may also be used in the methods and compositions of this invention. Univalent antibodies comprise a heavy chain/light chain dimer bound to the Fc (or stem) region of a second heavy chain. "Fab region"
15 refers to those portions of the chains which are roughly equivalent, or analogous, to the sequences which comprise the Y branch portions of the heavy chain and to the light chain in its entirety, and which collectively (in aggregates) have been shown to exhibit antibody activity. A Fab protein includes aggregates of one heavy and one light chain (commonly known as Fab'), as well as tetramers which correspond to the two branch
20 segments of the antibody Y, (commonly known as F(ab)2), whether any of the above are covalently or non-covalently aggregated, so long as the aggregation is capable of specifically reacting with a particular antigen or antigen family.

Any of the antibodies of the invention may optionally be conjugated to a chemotherapeutic, as defined below.

As used herein, the term “binding” means the physical or chemical interaction between two proteins or compounds or associated proteins or compounds or combinations thereof, including the interaction between an antibody and a protein. Binding includes ionic, non-ionic, hydrogen bonds, Van der Waals, hydrophobic interactions, etc. The physical interaction, the binding, can be either direct or indirect, indirect being through or due to the effects of another protein or compound. Direct binding refers to interactions that do not take place through or due to the effect of another protein or compound but instead are without other substantial chemical intermediates. Binding may be detected in many different manners. Methods of detecting binding are well-known to those of skill in the art.

As used herein, “an antibody capable of internalizing Cripto” means an antibody which enters the cell while removing Cripto from the cell surface. One can screen for Cripto antibodies which are capable of internalizing Cripto by using fluorescent labeled Cripto monoclonal antibodies. In order to determine which antibodies internalize into the Cripto positive cells one can assay for the uptake of the fluorescent signal of the antibodies into the cells by viewing the cells under a fluorescent and/or confocal microscope. Those antibodies that get internalized will be seen as fluorescent signals in the cytoplasmic and or cellular vesicles. Non-limiting examples of Cripto antibodies capable of internalizing Cripto include A27F6.1 and B3F6.17.

As used herein, the term “compound” means any identifiable chemical or molecule, including, but not limited to, ion, atom, small molecule, peptide, protein, sugar, nucleotide, or nucleic acid, and such compound can be natural or synthetic.

As used herein, the terms “modulates” or “modifies” means an increase or decrease in the amount, quality, or effect of a particular activity or protein.

As used herein, the term “modulate Cripto signaling” means an increase or decrease in the amount, quality, or effect of Cripto activity, by about 5%, preferably 10%, more preferably 20%, more preferably 30%, more preferably 40%, more preferably 50%, more preferably 60%, more preferably 70%, more preferably 80%,
5 more preferably 90%, and most preferably 100%,. Activity may be measured by assays known in the art, such as the null cell assay shown in Example 3. In another embodiment, protein interaction between Cripto and another protein is similarly modulated downward via binding of the antibodies of the invention.

As used herein, the term “blocking the interaction between Cripto and ALK 4”
10 means an increase or decrease in the interaction, i.e. binding, between Cripto and ALK4, by about 5%, preferably 10%, more preferably 20%, more preferably 30%, more preferably 40%, more preferably 50%, more preferably 60%, more preferably 70%, more preferably 80%, more preferably 90%, and most preferably 100%,. Activity may be measured by assays known in the art, such as the binding assay shown in
15 Example 8.

As used herein, the term “modulate growth of tumor cells *in vitro*” means an increase or decrease in the number of tumor cells, *in vitro*, by about 5%, preferably 10%, more preferably 20%, more preferably 30%, more preferably 40%, more preferably 50%, more preferably 60%, more preferably 70%, more preferably 80%,
20 more preferably 90%, and most preferably 100%. In vitro modulation of tumor cell growth may be measured by assays known in the art, such as the GEO cell soft agar assay shown in Example 4.

As used herein, the term “modulate growth of tumor cells *in vivo*” means an increase or decrease in the number of tumor cells, *in vivo*, by about 5%, preferably
25 10%, more preferably 20%, more preferably 30%, more preferably 40%, more

preferably 50%, more preferably 60%, more preferably 70%, more preferably 80%, more preferably 90%, and most preferably 100%. *In vivo* modulation of tumor cell growth may be measured by assays known in the art, such as the one shown in Example 5.

5 The term “preventing” refers to decreasing the probability that an organism contracts or develops an abnormal condition.

 The term “treating” refers to having a therapeutic effect and at least partially alleviating or abrogating an abnormal condition in the organism. Treating includes maintenance of inhibited tumor growth, and induction of remission.

10 The term “therapeutic effect” refers to the inhibition of an abnormal condition. A therapeutic effect relieves to some extent one or more of the symptoms of the abnormal condition. In reference to the treatment of abnormal conditions, a therapeutic effect can refer to one or more of the following: (a) an increase or decrease in the proliferation, growth, and/or differentiation of cells; (b) inhibition (*i.e.*, slowing or
15 stopping) or promotion of cell death; (c) inhibition of degeneration; (d) relieving to some extent one or more of the symptoms associated with the abnormal condition; and (e) enhancing the function of a population of cells. Compounds demonstrating efficacy against abnormal conditions can be identified as described herein.

 The term “administering” relates to a method of incorporating a compound into
20 cells or tissues of an organism. The abnormal condition can be prevented or treated when the cells or tissues of the organism exist within the organism or outside of the organism. Cells existing outside the organism can be maintained or grown in cell culture dishes, or in another organism. For cells harbored within the organism, many techniques exist in the art to administer compounds, including (but not limited to) oral,
25 parenteral, dermal, injection, and aerosol applications. For cells outside of the

organism, multiple techniques exist in the art to administer the compounds, including (but not limited to) cell microinjection techniques, transformation techniques and carrier techniques. Administration may be accomplished by the many modes known in the art, e.g., oral, intravenous, intraperitoneal, intramuscular, and the like. When used in *in vivo* therapy, the antibodies of the subject invention are administered to a patient in effective amounts. As used herein an "effective amount" is an amount sufficient to effect beneficial or desired clinical results (i.e., amounts that eliminate or reduce the patient's tumor burden). An effective amount can be administered in one or more administrations. For purposes of this invention, an effective amount of the antibodies of the present invention is an amount of the antibodies that is sufficient to ameliorate, stabilize, or delay the development of the Cripto-associated disease state, particularly Cripto-associated tumors. Detection and measurement of these indicators of efficacy are discussed below. An example of a typical treatment regime includes administering by intravenous infusion to the subject antibodies of the invention on a weekly schedule, at a dose of about 2-5 mg/kg. The antibodies are administered in an outpatient chemoinfusion unit, unless the patient requires hospitalization. Other administration regimes known in the art are also contemplated.

The abnormal condition can also be prevented or treated by administering an antibody of the invention to a group of cells having an aberration in a signal transduction pathway to an organism. The effect of administering a compound on organism function can then be monitored. The organism is preferably a human.

"Cripto overexpression" is intended to mean the expression of Cripto by a tissue which expression is greater than the Cripto expression of adjacent normal tissue in a statistically significant amount.

“Chemotherapeutics” refers to any agents identified in the art as having therapeutic effect on the inhibition of tumor growth, maintenance of inhibited tumor growth, and/or induction of remission, such as natural compounds, synthetic compounds, proteins, modified proteins, and radioactive compounds.

- 5 Chemotherapeutic agents contemplated herewith include agents that can be conjugated to the antibodies of the present invention or alternatively agents that can be used in combination with the antibodies of the present invention without being conjugated to the antibody. Exemplary chemotherapeutics that can be conjugated to the antibodies of the present invention include, but are not limited to radioconjugates (⁹⁰Y, ¹³¹I,
- 10 ^{99m}Tc, ¹¹¹In, ¹⁸⁶Rh, et al.), tumor-activated prodrugs (maytansinoids, CC-1065 analogs, clicheamicin derivatives, anthracyclines, vinca alkaloids, et al.), ricin, diphtheria toxin, pseudomonas exotoxin..

- Chemotherapeutic agents may be used in combination with the antibodies of the invention, rather than being conjugated thereto (i.e. nonconjugated chemotherapeutics),
- 15 include, but are not limited to the following: platinum (i.e. cis platinum), anthracyclines, nucleoside analogs (purine and pyrimidine), taxanes, camptothecins, epipodophyllotoxins, DNA alkylating agents, folate antagonists, vinca alkaloids, ribonucleotide reductase inhibitors, estrogen inhibitors, progesterone inhibitors, androgen inhibitors, aromatase inhibitors, interferons, interleukins, monoclonal
- 20 antibodies, taxol, camptosar, adriamycin (dox), 5-FU and gemcitabine. Such chemotherapeutics may be employed in the practice of the invention in combination with the antibodies of the invention by coadministration of the antibody and the nonconjugated chemotherapeutic.

- “Pharmaceutically acceptable carrier or excipient” refers to biologically inert
- 25 compounds known in the art and employed in the administration of the antibodies of

the invention. Acceptable carriers are well known in the art and are described, for example, in Remington's Pharmaceutical Sciences, Gennaro, ed., Mack Publishing Co., 1990. Acceptable carriers can include biocompatible, inert or bioabsorbable salts, buffering agents, oligo- or polysaccharides, polymers, viscoelastic compound such as

5 hyaluronic acid, viscosity-improving agents, preservatives, and the like.

A "subject" refers to vertebrates, particularly members of a mammalian species, and includes but is not limited to domestic animals, sports animals, and primates, including humans.

Antibodies of the Invention

10 The antibodies of the invention specifically bind to Cripto: As used herein, Cripto includes the CR-1 Cripto protein, the CR-3 Cripto protein, and fragments thereof. Such fragments may be entire domains, such as the extracellular or intracellular domains, the EGF-like domain, the cys-rich domain, the receptor binding domain, and the like. Such fragments may also include contiguous and noncontiguous

15 epitopes in any domain of the Cripto protein.

The 188 amino acid sequence for CR-1 is as follows [SEQ ID NO: 1]:

MDCRKMARFSYSVIWIMAISKVFELGLVAGLGHQEFARPSRGYLAFRDDS
IWPQEEPAIRPRSSQVRPPMGIQHSKELNRTCCLNGGTCMLGSFCACPPS
FYGRNCEHDVRKENCGSVPHDTWLPKKCSLCKCWHGQLRCFPQAFLPGCD
20 GLVMDEHLVASRTPELPPSARTTTFMLVGICLSIQSY

The 188 amino acid sequence for CR-3 is as follows [SEQ ID NO: 2]:

MDCRKMVRFSYSVIWIMAISKAFELGLVAGLGHQEFARPSRGDLAFRDDS
IWPQEEPAIRPRSSQVRVLPMGIQHSKELNRTCCLNGGTCMLESFCACPPSF
25 YGRNCEHDVRKENCGSVPHDTWLPKKCSLCKCWHGQLRCFPQAFLPGCDGL
VMDEHLVASRTPELPPSARTTTFMLAGICLSIQSY

In a one embodiment, the antibodies of the invention bind to an epitope in the EGF-like domain of Cripto. The EGF-like domain spans from about amino acid

30 residue 75 to about amino acid residue 112 of the mature Cripto protein. Epitopes in the EGF-like domain may comprise linear or nonlinear spans of amino acid residues.

Example of linear epitopes contemplated include but are not limited to about residues 75-85, 80-90, 85-95, 90-100, 95-105, 100-110, or 105-112. In one embodiment, the epitope in the EGF domain is an epitope formed in the conformational native Cripto protein versus a denatured Cripto protein.

5 In another embodiment, the antibodies of the invention bind to an epitope in the cys-rich domain of Cripto. The cys-rich domain spans from about amino acid residue 114 to about amino acid residue 150 of the mature Cripto protein. Epitopes in the cys-rich domain may comprise linear or nonlinear spans of amino acid residues. Example of linear epitopes contemplated include but are not limited to about residues 114-125,
10 120-130, 125-135, 130-140, 135-145, or 140-150. In one embodiment, the epitope in the cys-rich domain is an epitope formed in the conformational native Cripto protein versus a denatured Cripto protein

 Once antibodies are generated, binding of the antibodies to Cripto may be assayed using standard techniques known in the art, such as ELISA, while the presence
15 of Cripto on a cell surface may be assayed using flow cytometry (FACS), as shown in Example 2. Any other techniques of measuring such binding may alternatively be used.

 The present invention provides antibodies (*e.g.*, monoclonal and polyclonal antibodies, single chain antibodies, chimeric antibodies, bifunctional/bispecific
20 antibodies, humanized antibodies, human antibodies, and complementary determining region (CDR)-grafted antibodies, including compounds which include CDR sequences which specifically recognize a polypeptide of the invention) specific for Cripto or fragments thereof. Antibody fragments, including Fab, Fab', F(ab')₂, and F_v, are also provided by the invention. The terms "specific" and "selective," when used to describe
25 binding of the antibodies of the invention, indicates that the variable regions of the

antibodies of the invention recognize and bind Cripto polypeptides. It will be understood that specific antibodies of the invention may also interact with other proteins (for example, *S. aureus* protein A or other antibodies in ELISA techniques) through interactions with sequences outside the variable region of the antibodies, and, in particular, in the constant region of the molecule. Screening assays to determine binding specificity of an antibody of the invention (i.e. antibodies that specifically bind to an epitope the ligand/receptor binding domain and the domain spanning amino acid residues 46-62) are well known and routinely practiced in the art. For a comprehensive discussion of such assays, see Harlow *et al.* (Eds.), Antibodies A Laboratory Manual; Cold Spring Harbor Laboratory; Cold Spring Harbor, NY (1988), Chapter 6. Antibodies that recognize and bind fragments of Cripto protein are also contemplated, provided that the antibodies are specific for Cripto polypeptides. Antibodies of the invention can be produced using any method well known and routinely practiced in the art.

In one embodiment, the invention provides an antibody that specifically binds to an epitope in the ligand/receptor binding domain of Cripto. Antibody specificity is described in greater detail below. However, it should be emphasized that antibodies that can be generated from other polypeptides that have previously been described in the literature and that are capable of fortuitously cross-reacting with Cripto (*e.g.*, due to the fortuitous existence of a similar epitope in both polypeptides) are considered "cross-reactive" antibodies. Such cross-reactive antibodies are not antibodies that are "specific" for Cripto. The determination of whether an antibody specifically binds to an epitope of Cripto is made using any of several assays, such as Western blotting assays, that are well known in the art. For identifying cells that express Cripto and also for modulating Cripto ligand/receptor binding activity, antibodies that specifically bind

to an extracellular epitope of the Cripto protein (i.e., portions of the Cripto protein found outside the cell) are particularly useful.

In one embodiment, the invention provides a cell-free composition comprising polyclonal antibodies, wherein at least one of the antibodies is an antibody of the invention specific for Cripto. Antisera isolated from an animal is an exemplary composition, as is a composition comprising an antibody fraction of an antisera that has been resuspended in water or in another diluent, excipient, or carrier.

In another embodiment, the invention provides monoclonal antibodies. Monoclonal antibodies are highly specific, being directed against a single antigenic site. Further in contrast to polyclonal preparations which typically include different antibodies directed against different epitopes, each monoclonal antibody is directed against a single determinant on the antigen. Monoclonal antibodies are useful to improve selectivity and specificity of diagnostic and analytical assay methods using antigen-antibody binding. Another advantage of monoclonal antibodies is that they are synthesized by a hybridoma culture, uncontaminated by other immunoglobulins. Hybridomas that produce such antibodies are also intended as aspects of the invention.

In still another related embodiment, the invention provides an anti-idiotypic antibody specific for an antibody that is specific for Cripto. For a more detailed discussion of anti-idiotypic antibodies, see, e.g., U.S. Patents 6,063,379 and 5,780,029.

It is well known that antibodies contain relatively small antigen binding domains that can be isolated chemically or by recombinant techniques. Such domains are useful Cripto binding molecules themselves, and also may be reintroduced into human antibodies, or fused to a chemotherapeutic or polypeptide. Thus, in still another embodiment, the invention provides a polypeptide comprising a fragment of a Cripto-specific antibody, wherein the fragment and associated molecule, if any, bind to the

Cripto. By way of non-limiting example, the invention provides polypeptides that are single chain antibodies and CDR-grafted antibodies. For a more detailed discussion of CDR-grafted antibodies, see, e.g., U.S. Patent 5,859,205.

In another embodiment, non-human antibodies may be humanized by any of the methods known in the art. Humanized antibodies are useful for *in vivo* therapeutic applications. In addition, recombinant "humanized" antibodies may be synthesized. Humanized antibodies are antibodies initially derived from a nonhuman mammal in which recombinant DNA technology has been used to substitute some or all of the amino acids not required for antigen binding with amino acids from corresponding regions of a human immunoglobulin light or heavy chain. That is, they are chimeras comprising mostly human immunoglobulin sequences into which the regions responsible for specific antigen-binding have been inserted (see, e.g., PCT patent application WO 94/04679). Animals are immunized with the desired antigen, the corresponding antibodies are isolated and the portion of the variable region sequences responsible for specific antigen binding are removed. The animal-derived antigen binding regions are then cloned into the appropriate position of the human antibody genes in which the antigen binding regions have been deleted. Humanized antibodies minimize the use of heterologous (inter-species) sequences in antibodies for use in human therapies, and are less likely to elicit unwanted immune responses. Primatized antibodies can be produced similarly using primate (e.g., rhesus, baboon and chimpanzee) antibody genes. Further changes can then be introduced into the antibody framework to modulate affinity or immunogenicity. See, e.g., U.S. Patent Nos. 5,585,089, 5,693,761, 5,693,762, and 6,180,370.

Another embodiment of the invention includes the use of human antibodies, which can be produced in nonhuman animals, such as transgenic animals harboring one

or more human immunoglobulin transgenes. Such animals may be used as a source for splenocytes for producing hybridomas, as is described in United States patent 5,569,825, WO00076310, WO00058499 and WO00037504 and incorporated by reference herein.

5 **Signal Modulation**

In another embodiment, the antibodies of the invention bind to Cripto, and modulate Cripto signaling or Cripto-protein interactions. Over-expression of Cripto activity can lead to a de-differentiated state promoting mesenchymal cell characteristics, increased proliferation, and cell migration (Salomon et al., BioEssays 10 21: 61-70, 1999; Ciardiello et al., Oncogene 9: 291-298, 1994; and Baldassarre et al., Int. J. Cancer 66:538-543, 1996), phenotypes associated with cell transformation seen in neoplasia.

One method of testing the activity of anti-Cripto antibodies and their ability to modulate Cripto signaling is with an F9-Cripto knock-out (KO) cell line (Minchiotti at 15 al., Mech. Dev. 90: 133-142, 2000). Cripto stimulates smad2 phosphorylation and the transcription factor FAST in *Xenopus* embryos, and the activity of the transcription factor FAST can be monitored by measuring the luciferase activity from a FAST regulatory element-luciferase reporter gene (Saijoh et al., Mol. Cell 5:35-47, 2000). F9-Cripto KO cells are deleted for the Cripto gene and are thus null for Cripto and 20 Cripto-dependent signaling (Minchiotti et al., Mech. Dev. 90: 133-142, 2000). Cripto signaling can be assessed in the F9 Cripto KO cells by transfecting in Cripto, FAST, and the FAST regulatory element-luciferase gene construct. No Cripto dependent FAST luciferase activity will be seen in these cell lines unless Cripto cDNA, and FAST cDNA is transfected into them. Antibodies capable of blocking Cripto-dependent 25 Nodal signaling are antibodies that block Cripto signaling function.

Other assays capable of measuring the activity of Cripto can be employed by those of skill in the art, such as a growth in soft agar assay (see Example 4 below). The ability of cells to grow in soft agar is associated with cell transformation and the assay is a classical in vitro assay for measuring inhibition of tumor cell growth. Other assays
5 useful in determining inhibition of activity include in vitro assays on plastic, and the like.

Therapeutic Uses

Antibodies of the invention are also useful for, therapeutic purposes, such as modulation of tumor cell growth, diagnostic purposes to detect or quantitate Cripto, and
10 purification of Cripto.

In one embodiment of the invention, antibodies are provided which are capable of binding specifically to Cripto and which modulate growth of tumor cells in a patient. In one embodiment, the tumor cells are testicular, breast, testicular, colon, lung, ovary, bladder, uterine, cervical, pancreatic, and stomach tumor cells.

15 In another embodiment, antibodies are provided which are capable of binding specifically to Cripto and which modulate growth of tumor cells which overexpress Cripto. In one embodiment, the tumor cells are cell lines which overexpress Cripto, such as cell lines derived from breast, testicular, colon, lung, ovary, bladder, uterine, cervical, pancreatic, and stomach cancer.

20 Anti-Cripto antibodies may be screened for in vivo activity as potential anticancer agents following standard protocols used by those of skill in the art, as illustrated in Example 4 below. Example of such protocols are outlined by the National Cancer Institute (NCI) in their "*in vivo* cancer models screening" protocols, NIH publication number 84-2635 (Feb 1984).

In another embodiment of the invention, the antibodies of the invention are used to treat a patient having a cancerous tumor.

The antibodies of the present invention can be combined with a pharmaceutically acceptable excipient and administered in a therapeutically effective dose to the patient. For a discussion of methods of inhibiting growth of tumors, see, e.g., U.S. Patent 6,165,464.

Also contemplated are methods of treating a subject suffering from a disorder associated with abnormal levels (i.e. elevated or depleted) of Cripto wherein the method comprises administering to the subject an effective amount of an antibody that specifically binds to an epitope in the ligand/receptor binding domain of Cripto, including but not limited to where the epitope is in an EGF-like domain or a cys-rich domain of Cripto.

Also contemplated are methods of treating a subject suffering from a disorder associated with abnormal levels (i.e. elevated or depleted) of Cripto wherein the method comprises administering to the subject an effective amount of an antibody which specifically forms a complex with Cripto and is directed to the epitope to which an antibody selected from the group consisting of A6C12.11, A6F8.6 (ATCC ACCESSION NO. PTA-3318), A7H1.19, A8F1.30, A8G3.5 (ATCC ACCESSION NO. PTA-3317), A8H3.1 (ATCC ACCESSION NO. PTA-3315), A8H3.2, A19A10.30, A10B2.18 (ATCC ACCESSION NO. PTA-3311), A27F6.1 (ATCC ACCESSION NO. PTA-3310), A40G12.8 (ATCC ACCESSION NO. PTA-3316), A2D3.23, A7A10.29, A9G9.9, A15C12.10, A15E4.14, A17A2.16, A17C12.28, A17G12.1 (ATCC ACCESSION NO. PTA-3314), A17H6.1, A18B3.11 (ATCC ACCESSION NO. PTA-3312), A19E2.7, B3F6.17 (ATCC ACCESSION NO. PTA-3319), and B6G7.10 (ATCC ACCESSION NO. PTA-3313) is directed.

Diagnosis via detection of Cripto is readily accomplished through standard binding assays using the novel antibodies of the invention, allowing those of skill in the art to detect the presence of Cripto specifically in a wide variety of samples, cultures, and the like.

5 Kits comprising an antibody of the invention for any of the purposes described herein are also comprehended. In general, a kit of the invention also includes a control antigen for which the antibody is immunospecific. Embodiments include kits comprising all reagents and instructions for the use thereof.

Additional features of the invention will be apparent from the following
10 illustrative Examples.

Examples

Example 1: Expression and Purification of Cripto

An expression plasmid designated pSGS480 was constructed by sub-cloning a cDNA encoding human Cripto amino acids residues 1 to 169 of Cripto [amino acids 1-
15 169 of SEQ ID NO: 1], fused to human IgG₁ Fc domain (i.e., "CR(del C)-Fc") into vector pEAG1100. For a more detailed description of this vector, see copending U.S. Patent Application Serial No. 60/233,148, filed September 18, 2000. The vector pEAG1100 is a derivative of GIBCO-BRL Life Technologies plasmid pCMV-Sport-betagal, the use of which in CHO transient transfections was described by Schifferli et
20 al., 1999, Focus 21: 16. It was made by removing the reporter gene beta-galactosidase NotI fragment from the plasmid pCMV-Sport-Betagal (catalog number 10586-014) as follows: The plasmid was digested with NotI and EcoRV, the 4.38 kb NotI vector backbone fragment was gel-purified and ligated. Ligated DNA was transformed into competent *E. coli* DH5alpha. pEAG1100 was isolated as a plasmid containing the
25 desired recombinant from an isolated single colony. The sequence of pEAG1100 spanning the promoter, polylinker, and transcription termination signal was confirmed.

Plasmid pSGS480 was transiently transfected into CHO cells and the cells were grown at 28°C for 7 days. The presence of CR(del C)-Fc protein in these cells and the conditioned media was examined by Western blot analysis. For Western blot analysis, conditioned media and cells from Cripto transfected cells were subjected to SDS-PAGE
5 on 4-20% gradient gels under reducing conditions, transferred electrophoretically to nitrocellulose, and the Cripto fusion protein was detected with a rabbit polyclonal antiserum raised against a Cripto 17-mer peptide (comprising residues 97-113 of SEQ ID NO: 1)-keyhole limpet hemocyanin conjugate. After centrifugation to remove the cells, Western blot analysis showed that the CR(del C)-Fc protein was efficiently
10 secreted into the conditioned media (supernatant). The supernatant was applied to a Protein A-Sepaharose (Pharmacia), and bound protein was eluted with 25 mM sodium phosphate pH 2.8, 100 mM NaCl. The eluted protein was neutralized with 0.5 M sodium phosphate at pH 8.6, and analyzed for total protein content from absorbance measurements at 240-340 nm, and for purity by SDS-PAGE. The eluted protein was
15 filtered through a 0.2 micron filter, and stored at -70°C.

Example 2: Generation and Screening of Antibodies

The eluted CR(del C)-Fc protein is injected into mice, and standard hybridoma
20 techniques known to those of skill in the art are used to generate monoclonal antibodies.

A. Generation of Antibodies

Particularly, female Robertsonian mice (Jackson Labs) were immunized intraperitoneally with 25 µg of purified human CR del C-Fc emulsified with complete
25 freund's adjuvant (GibcoBRL #15721-012). They were boosted two times intraperitoneally with 25 µg of CR del C -Fc emulsified with incomplete freunds's

adjuvant (GibcoBRL #15720-014) and once on Protein A beads. The sera were screened and 3 weeks after the last boost, the mouse with the best titer was boosted intraperitoneally with 50 µg soluble CR del C-Fc three days before fusion. The mouse was boosted intravenously with 50 µg CR del C-Fc the day before fusion. The mouse
5 spleen cells were fused with FL653 myeloma cell at a 1spleen :6 myeloma ratio and were plated at 100,000, 33,000 and 11,000 cells per well into 96 well tissue culture plates in selection media. Wells positive for growth were screened by FACS and ELISA a week later. Two fusions were performed.

B. Screening of Antibodies

10 Supernatants resulting from the first or second fusion were screened first on ELISA plates for recognition of Cripto del C and/or Cripto EGF-like domain proteins. A control fusion protein (LT-beta receptor-Fc) was coated on ELISA plates to discard monoclonal antibodies that recognized the human Fc epitope. The ELISA was performed as described below in section C. In the first fusion, primary supernatants
15 were also screened for their ability to recognize cell surface Cripto protein on the testicular tumor cell line, NCCIT by FACS. In the case of the second fusion, the ability of supernatants to recognize Cripto on two tumor cell lines, NCCIT and the breast cancer line, DU4475 by FACS was analyzed. Secondary screens included testing the monoclonal antibody supernatant's ability to recognize cell surface Cripto on a
20 panel of tumor cell lines (see Tables 1 and 2 for results), ability of monoclonal antibodies to recognize human Cripto immunohistochemically on human breast and colon tumor tissue sections, ability of monoclonal antibodies to block in Cripto-Nodal signalling assay, ability to block growth of tumor cell lines on plastic or in soft agar assays, and ability to internalize cell surface Cripto.

C. ELISA

The ELISA assays were performed as follows:

Materials:

Plates: Costar high-binding Easy-wash 96W plates (07-200-642)

2' antibody: Pierce Gt anti- Ms IgG (H+L)- HRP (P131430)

5 Substrate: Pierce TMB Substrate Kit (34021)

Stop solution: 1N H₂SO₄

Buffers:

Binding buffer: 0.1 M NaHPO₄ pH 9.0

Blocking buffer: PBS + 10% Donor Calf Serum

10 Wash buffer: PBS + 0.1% tween-20

Antigens CR-del-C-Fc and CR-EGF-fc, control hu IgG1 fusion protein were diluted in binding buffer to 500ng/ml. 100 µl were added per well and incubated for 1 hr at 37° C or overnight at 4° C. The liquid was decanted and the plate inverted and blotted until dry. 250 µl/well blocking buffer was then added, followed by incubation for 30 min. at 37° C. Again, the liquid was decanted and the plate inverted and blotted until dry. Supernatants were diluted 1:50 in wash buffer, and plated at 50 µl/well, followed by incubation for 1 hour at room temperature. Plates were washed 3X vigorously with 250 µl/well wash buffer. Then 100 µl/well 2' antibody diluted in wash buffer at 1:10,000 was added, followed by incubation for 30 min. at room temperature. 15 Plates were then washed 3X vigorously with 250 µl/well wash buffer, then substrate added at 100µl/well. Color was permitted to develop until sufficiently dark, then 100 µl/well stop solution was added and the plates read for absorbance at 450nm.

D. Flow Cytometry

Cripto positive cell lines may be used to assay the monoclonal antibodies for binding to Cripto using cell surface staining and flow cytometry as follows:

25

Release cells from T162 flasks with 2 ml PBS⁻ with 5 mM EDTA, 10 min., 37°C. Bring up to 20 ml with media with serum, pipetting up and down several times to unclump cells. Spin at 1200 rpm for 5 minutes. Wash cells with 5-10 ml 4°C PBS with 0.1% BSA (wash buffer). Spin at 1200 rpm for 5 minutes. Resuspend at 4×10^6 -
5 10^7 /ml in wash buffer. Keep on ice.

Prepare antibodies for staining. Purified antibodies are diluted to 1-10 µg/ml in wash buffer. Add 50 µl of cells to a 96-well Linbro V bottomed plate (ICN 7632105). Plate one well of cells for each control for each cell line to be analyzed, including cells for no antibody, 2° antibody only, hybridoma media, positive control antibody
10 supernatant, if available, or purified, and an IgG subclass control (if using purified antibodies).

Plate one well of cells for each experimental sample for each cell line to be analyzed. Spin plate, 1200 rpm for 5 minutes, using a table top centrifuge at 4°C. Flick out buffer by inverting the plate and shaking until the liquid is substantially
15 discarded. Add 40-50 µl of antibodies (or wash buffer for the no-antibody and 2° antibody-only control wells) to wells. Incubate at least 30 min.-1 hour at 4°C. Spin plate, 1200 rpm for 5 minutes. Flick out antibody solutions. Wash wells twice with 200 µl wash buffer per well, spinning after each wash. Flick out buffer.

Resuspend cells in each well in 50 µl of 1:200 dilution (in wash buffer) of R-PE
20 tagged goat anti-mouse IgG, Fc Specific (Jackson ImmunoResearch Laboratories Cat# 115-116-071). Incubate 20 min, 4°C, in the dark. Add 150 µl wash buffer to cells in each well. Spin plate at 1200 rpm for 5 minutes. Wash once with 200 µl wash buffer per well. Resuspend cells in 150 µl 1% PFA in PBS. Transfer contents of each well to separate tubes (5 ml Falcon polystyrene round bottomed tube-352052). Wrap tubes in
25 tin foil.

The contents of the tubes are then read by flow cytometry.

The results of a two screenings of monoclonal antibodies produced by this method yielded the following results, summarized in Tables 1 and 2 below, wherein the first column provides the designated names for the hybridoma subclones, the next two
 5 columns show the results of ELISA screens, and the remaining columns show flow cytometry analysis results on four cripto-positive cell lines. The results are given in units of mean fluorescent index (MFI).

Table 1: Anti-Cripto Monoclonal Antibody Characterization

Hybridoma Subclone	ATCC deposit no.	ELISA Cripto delC Sups	ELISA Cripto EGFlake domain Sups	DU4475 MFI	NCCIT MFI	GEO MFI	HT3 MFI
Control-ELISA		0.06	0.07				
Control-MouseIg				14	9	37	18
A6C12.11		2.21	0.07	11	35	29	8
A6F8.6	PTA-3318	2.32	0.08	11	50	29	10
A7H1.19		2.14	0.09	14	34	27	12
A8F1.30		2.15	0.1	17	27	32	28
A8G3.5	PTA-3317	2.39	0.09	9	30	25	15
A8H3.1	PTA-3315	2.4	1.7	9	44	23	10
A8H3.2		2.54	0.07	13	13	16	14
A19A10.30		2.02	0.09	9	40	20	10
A10B2.18	PTA-3311	2.36	0.07	40	63	100	43
A27F6.1	PTA-3310	2.28	1.19	9	44	26	17
A40G12.8	PTA-3316	2.27	1.59	10	47	26	16

10

Table 2: Anti-Cripto Monoclonal Antibody Characterization

Hybridoma Subclone	ATCC deposit no.	ELISA Cripto delC	ELISA Cripto EGFlake domain	DU4475 MFI	NCCIT MFI	GEO MFI	HT3 MFI
Control-ELISA		0.05	0.05				
Control-MouseIg				10	6	4	6
A2D3.23		0.93	0.90	73	138	37	27
A7A10.29		1.37	0.07	75	83	33	83
A9G9.9		1.39	0.07	52	62	32	82
A15C12.10		1.42	0.06	46	55	25	93
A15E4.14		1.38	0.06	50	63	23	95
A17A2.16		1.40	0.06	76	97	41	81
A17C12.28		0.96	0.97	6	16	3	22
A17G12.1	PTA-3314	1.30	1.37	61	66	28	78
A17H6.1		1.38	0.05	35	30	5	28
A18B3.11	PTA-3312	1.36	1.38	50	42	33	65
A19E2.7		1.40	0.06	53	59	26	99
B3F6.17	PTA-3319	1.37	0.06	77	51	39	89
B6G7.10	PTA-3313	1.38	1.40	28	22	22	56
B11H8.4		1.41	0.06	59	101	39	107
B12C12.5		1.10	1.04	27	14	23	59
B15A2.6		1.40	0.06	36	44	22	59
C4A2.16		1.40	0.06	24	36	22	65

5 Example 3: Null Cell Assay for Inhibition of Cripto Signaling

The following describes an F9 Cripto null cell signaling assay used to assess inhibition of Cripto signaling.

Day 0 Coat 6 well plates with 0.1% gelatin 2ml/well at 37°C for 15 min.

Seed cells at 6×10^5 F9 CRIPTO NULL cells per well.

10 *Day 1* Transfection:

Each of the following samples is added to 300 μ l OptiMem1 to yield Solution A for each sample:

Sample 1: 0.5 μ g (N₂)₇ luciferase FAST reporter cDNA plus 1.5 μ g empty vector cDNA.

15 Sample 2: 0.5 μ g (N₂)₇ luciferase, 0.5 μ g FAST, and 1 μ g empty vector cDNAs.

Sample 3: 0.5µg (N₂)₇ luciferase, 0.5µg Cripto ADD 0.5 FAST, and 10.5µg empty vector cDNAs.

Sample 4: 0.5µg (N₂)₇ luciferase, 0.5µg Cripto, 0.5 FAST, and 0.5 µg empty vector cDNAs

- 5 Sample 5: 0.5µg (N₂)₇ luciferase, 0.5µg Cripto, 0.5 FAST, and 0.5 µg empty vector cDNAs.

Sample 6: 0.5µg (N₂)₇ luciferase, 0.5µg Cripto, 0.5 FAST, and 0.5 µg empty vector cDNAs.

- 10 Sample 7: 0.5µg (N₂)₇ luciferase, 0.5µg Cripto, 0.5 FAST, and 0.5 µg empty vector cDNAs.

Sample 8: 0.5µg (N₂)₇ luciferase, 0.5µg Cripto, 0.5 FAST, and 0.5 µg empty vector cDNAs.

Sample 9: 0.5µg (N₂)₇ luciferase, 0.5µg Cripto, 0.5 FAST, and 0.5 µg empty vector cDNAs.

- 15 Solution B comprises 30 µl of Lipofectamine plus 270 µl of OptiMem1.

For each sample, mix solution A and solution B together. Incubate 45 minutes at room temperature. Rinse wells with 2 ml/well of OptiMem1. Aspirate just before next step.

- Add 2.4 ml of OptiMem1 to each mixture of solutions A+B, mix, add 1.5 ml/well to
20 duplicate wells. Incubate 5 hours at 37°C. Add 1.5 ml/well of DMEM+20% FCS, 2mM Gln, P/S to wells which received samples 1-3. Add anti-Cripto antibodies as follows: Sample 4 wells: A27F6.1, 10 µg/ml; Sample 5 wells: A27F6.1, 2µg/ml; Sample 6 wells: A40G12.8; 10µg/ml, Sample 7 wells: A40G12.8 2µg/ml; Sample 8 wells: A10B2.18, 10µg/ml; Sample 9 wells: A10B2.18, 2µg/ml.

Day 2 Remove media, wash cells with PBS, 2ml/well. Add DMEM+0.5% FCS, 2mM Gln, P/S with the same amounts of Cripto antibodies as the previous day, to the same wells.

Day 3 Develop luciferase signal. Wash wells with PBS+Ca²⁺ and Mg²⁺, 2 ml/well. Use LucLite kit, Packard cat# 6016911. Bring buffer and substrate to room temperature. Dim lights. Reconstitute substrate with 10 ml of buffer. Dilute 1:1 with PBS + Ca²⁺ and Mg²⁺. Aspirate wells. Quickly add 250 µl of diluted substrate per well using a repeat pipettor. Swirl solution and transfer 200 µl to wells of a 96 well white opaque bottom plate, Falcon 35-3296. Read plate on luminometer using Winglow, exporting data to Excel.

The results of this assay are summarized below in Table 3.

Table 3: Cripto Signaling Assay: Inhibition with Anti-Cripto Monoclonal Antibodies

cDNAs transfected	Anti-Cripto Antibody	Relative Luminescent Units
(N ₂) ₇ luc	none	123
(N ₂) ₇ luc, FAST	none	259
(N ₂) ₇ luc, FAST, Cripto	none	3091
(N ₂) ₇ luc, FAST, Cripto	A27F6.1 10µg/ml	1507
(N ₂) ₇ luc, FAST, Cripto	A27F6.1 2µg/ml	2297
(N ₂) ₇ luc, FAST, Cripto	A40G12.8 10µg/ml	1213
(N ₂) ₇ luc, FAST, Cripto	A40G12.8 2µg/ml	2626
(N ₂) ₇ luc, FAST, Cripto	A10B2.18 10µg/ml	3466
(N ₂) ₇ luc, FAST, Cripto	A10B2.18 2µg/ml	3103

15 **Example 4: Assay for *In Vitro* Inhibition of Tumor Cell Growth**

Inhibition of Cripto Signaling may also be assayed by measuring the growth of GEO cells in soft agar. See, e.g., Ciardiello et al., *Oncogene*. 1994 Jan;9(1):291-8; Ciardiello et al., *Cancer Res*. 1991 Feb 1;51(3):1051-4.

First, melt 3% bactoagar. Keep at 42 °C in a water bath. Then, mix 3% bactoagar solution with prewarmed complete media to make a solution of 0.6% bactoagar, keeping at 42 °C. Plate 4 mls of the solution in a 6 cm dish and let cool for

at least 30 minutes to form the bottom agar layer. Trypsinize GEO cells and resuspend to 10^5 cells/ml in complete media. Add antibodies to be assayed, or controls, to the cell suspensions, titrating antibodies from 20 μ g to 1 μ g. Mix equal volumes of the GEO cell suspensions and 0.6% bactoagar and overlay 2 mls on top of the bottom agar layer.

- 5 Let cool for at least 1 hour. Incubate for 14 days at 37 °C in CO₂ incubator. Count colonies visible without the use of a microscope. The absence of colonies, as compared to negative controls, indicates that the antibody tested inhibits in vitro tumor cell growth.

This assay was used to yield the results shown in Table 4, for the antibodies

- 10 A27F6.1 and B6G7.10, both of which demonstrate the ability to decrease growth of GEO cell colonies.

Table 4: Results of growth in soft agar assay

Antibody	Average number of colonies
none	109.0
none	104.3
A27.F6 20 μ g/ml	82.0
A27F6.1 10 μ g/ml	78.3
A27F6.1 5 μ g/ml	79.0
A27F6.1 1 μ g/ml	108.7
B6G7.10 20 μ g ml	102.3
B6G7.10 10 μ g/ml	71.7

Example 5: Assay for *In Vivo* Inhibition of Tumor Cell Growth

- 15 To assess the inhibition of tumor cell growth, a human tumor cell line is implanted subcutaneously in athymic nude mice and the effects of the antibodies of the invention are observed, with and without additional chemotherapeutic treatments which may provide synergistic or additive effects on tumor inhibition.

This assay may be performed alternatively using different tumor cell lines, such as, for example, GEO (a well differentiated human colon cancer in-vitro cell line, is obtained from the American Tissue Type Collection (ATCC)), DU-4475 (a breast cancer in-vitro cell line obtained from the ATCC), NCCIT (a testicular tumor cell line obtained from ATCC), or others known in the art. One example of such assays is as follows:

Animals are individually marked by ear punches. The GEO cell line is passed in-vitro or in-vivo for 1-4 passages. Animals are implanted with GEO cells subcutaneously in the right flank area. The following groups of animals may be used:

Group #	Treatment	# of Mice
1.	Saline Control, 0.2 ml/mouse, i.p. three times weekly (M,W,F)	20
2.	mAb, low dose, i.p.	10
3.	mAb, middle dose, i.p.	10
4.	mAb, high dose, i.p.	10
5.	5-FU, 30 mg/kg/inj, i.p., 3 Rx/wk (M,W,F)	10
6.	Cisplatin, 2 mg/kg/inj, s.c., 3 Rx/wk (M,W,F)	10
7.	Adriamycin, 1.6 mg/kg/inj, i.p., 3 Rx/wk (M,W,F)	10
8.	Irinotecan, 10 mg/kg/inj., i.p., 5 Rx/wk (M-F)	10
9.	mAb, low dose, i.p. + 5-FU (intermediate dose)	10
10.	mAb, middle dose, i.p. + 5-FU (intermediate dose)	10
11.	mAb, high dose, i.p. + 5-FU (intermediate dose)	10
12.	mAb, low dose, i.p. + Cisplatin (intermediate dose)	10
13.	mAb, middle dose, i.p. + Cisplatin (intermediate dose)	10
14.	mAb, high dose, i.p. + Cisplatin (intermediate dose)	10
15.	mAb, low dose, i.p. + Adriamycin (intermediate dose)	10

- | | | | |
|---|-----|--|----|
| | 16. | mAb, middle dose, i.p. + Adriamycin (intermediate dose) | 10 |
| | 17. | mAb, high dose, i.p. + Adriamycin (intermediate dose) | 10 |
| | 18. | mAb, low dose, i.p. + Irinotecan (intermediate dose) | 10 |
| | 19. | mAb, middle dose, i.p. + Irinotecan (intermediate dose) | 10 |
| 5 | 20. | mAb, high dose, i.p. + Irinotecan (intermediate dose) | 10 |

Day 0: Implant tumor, record initial body weight of animals.

Day 1: Initiate treatments as indicated above.

Day 5: Begin tumor size and body weight measurements and continue two
10 times weekly until termination of experiment.

Initial body weight, tumor size and body weight measurements, histology at sacrifice, and immunohistochemistry analysis on tumors are examined, analyzing for Cripto expression, tumor growth, and inhibition thereof.

15 **Example 6: In Vivo Xenograft Tumor Model – Cys-rich blocking anti-Cripto antibody**

To assess the response of an NCCIT, a human testicular carcinoma cell line was implanted subcutaneously with an antibody which binds to a cys-rich domain of Cripto.

The experimental methods are listed below. The results are shown in Figure 1.

20 Methods and Materials

Animals: Athymic nude male mice were used. Animals were individually numbered by ear punches.

25 Tumor:NCCIT, mediastinal mixed germ cell human testicular carcinoma in-vitro cell line originally obtained from the American Tissue Type Collection. Cell line was passed in-vitro for six passages in RPMI-1640/ 10% FBS without antibiotics. Animals implanted subcutaneously with 5×10^6 cells / 0.2 ml matrigel on the animals right flank.

Group #	Treatment	# of Mice
1	Vehicle Control, (25 mM sodium phosphate, 100 mM sodium chloride, pH 7.2), 0.2 ml/mouse, i.p., Q14D	20
5	Treatments begin on day -1	
2.	A8G3.5, 1 mg/kg/inj, i.p., Q14D	10
	Treatments begin on day -1	
10	3. A8G3.5, 3 mg/kg/inj, i.p., Q14D	10
	Treatments begin on day -1	
	4. A8G3.5, 10 mg/kg/inj, i.p., Q14D	10
	Treatments begin on day -1	
15	5. Cis-platinum, 2 mg/kg/inj, s.c., 3 x/wk (M,W, F) for 6 treatments	10
	Treatments began on day 1	
20	Testing schedule	
	Day -1: Randomized mice into control and treatments groups. Recorded initial body weight of animals. Administered first treatments to antibody groups. Dosing solutions were made. Treatments were blinded to the technicians until the assay was terminated.	
25	Day 0: Implanted tumor. Ran bacterial cultures on the tumor implanted into mice.	
	Day 1: Administered first treatment to the positive chemotherapeutic group.	
30	Day 4: Recorded initial tumor size measurements for tumor baseline on matrigel. Continued to record tumor size and body weights on mice 2x / week. Monitored the study daily and made notations of any unusual observation on animals.	
35	Endpoints: Initial body weight Tumor size and body weight measurements	

40 **Example 7: In Vivo Xenograft Tumor Model – EGF-like domain blocking anti-Cripto antibody**

To assess the response of an NCCIT, a human testicular carcinoma cell line was implanted subcutaneously with an antibody which binds to a EGF-like domain of Cripto. The experimental methods are listed below. The results are shown in Figure 2.

Methods and Materials:

Animals: Athymic nude male mice were used. Animals were individually numbered by ear punches.

- 5 Tumor: NCCIT, mediastinal mixed germ cell human testicular carcinoma in-vitro cell line originally obtained from the American Tissue Type Collection. Cell line was passed in-vitro for eight passages in RPMI-1640/ 10% FBS without antibiotics. Animals implanted subcutaneously with 5×10^6 cells / 0.2 ml matrigel on the animals right flank.

10

Group #	Treatment	# of Mice
1.	Vehicle Control, (25 mM sodium phosphate, 100 mM sodium chloride, pH 7.2), 0.2 ml/mouse, i.p., Q14D Treatments begin on day -1	18
15 2.	A27F6.1, 1 mg/kg/inj, i.p., Q14D Treatments begin on day -1 with a loading dose of 2.6 mg/kg/mouse	10
20 3.	A27F6.1, 10 mg/kg/inj, i.p., Q14D Treatments begin on day -1 with a loading dose of 21.2 mg/kg/mouse	10
4.	Cis-platinum, 2 mg/kg/inj, s.c., 3 x/wk (M,W, F) for 6 treatments	10

Treatments began on day 1.

25

Testing schedule

Day -1: Randomized mice into control and treatments groups. Recorded initial body weight of animals. Administered first treatments to antibody groups. Dosing solutions were made. Treatments were blinded to the technicians until the assay was terminated.

30

Day 0: Implant tumor. Ran bacterial cultures on the tumors implanted into mice. Bacterial culture were negative for contamination at 24 and 48 hours post sampling.

35

Day 1: Administered first treatment to the positive chemotherapeutic group.

Day 4: Recorded initial tumor size measurements for tumor baseline on matrigel. Continued to record tumor size and body weights on mice 2x / week. Monitored the study daily and made notations of any unusual observation on animals.

40

Endpoints:

45

Initial body weight
Tumor size and body weight measurements

Example 8: Cripto mabs that block ALK4 binding

In order to assess whether Cripto-specific monoclonal antibodies can interfere with Cripto's ability to bind to Alk4, the activin type I receptor, we used flow cytometry analysis using a 293 cell line which stably expresses Alk4. To generate this cell line,

5 293 cells were cotransfected with a plasmid that expresses Alk4 tagged at the C-terminus with a HA epitope and a plasmid that expresses the drug, puromycin, at a 10:1 ratio. The transfected cells were then selected in puromycin until colonies formed. Colonies were then picked, expanded and then analyzed for Alk4 expression using western blotting analysis for HA. Clone 21 (293-Alk4-21) was found to express high

10 levels of Alk4 compared to control, untransfected 293 cells.

To analyze Cripto-Alk4 binding by flow cytometry, a purified, soluble form of human Cripto (aa 1-169) fused to the Fc portion of human IgG (CrdelC-Fc) was employed. Approximately 5 μ g/ml of CrdelC-Fc or control Fc protein was incubated with 3x10⁵ 293-Alk4-21 cells on ice for 30 minutes in 50 μ l total volume of FACS

15 buffer (PBS with 0.1% BSA). For samples containing anti-Cripto antibodies, 5 μ g/ml CrdelC-Fc was preincubated with 50 μ g/ml of each Cripto antibody (A10.B2.18, A40.G12.8, A27.F6.1, A8.H3.1, A19.A10.30, A6.F8.6, A8.G3.5, A6.C12.11) on ice prior to addition of the cells. The cells were then washed in FACS buffer and the bound Fc protein was detected by incubating the cells with a R-phycoerytherin-conjugated

20 goat anti-human IgG (Fc fragment specific) from Jackson Immunologics. Samples were then washed again, fixed in 1% paraformaldehyde in PBS, and analyzed using standard flow cytometry procedures. The results of the FACS assay are shown in Figure 3.

Some of the embodiments of the invention described above are outlined below and include, but are not limited to, the following embodiments. As those skilled in the

25 art will appreciate, numerous changes and modifications may be made to the various

embodiments of the invention without departing from the spirit of the invention. It is intended that all such variations fall within the scope of the invention.

The entire disclosure of each publication cited herein is hereby incorporated by reference.

We claim:

1. An antibody that specifically binds to an epitope in the ligand/receptor binding domain of Cripto.
2. The antibody of claim 1 wherein the Cripto is selected from the group consisting of SEQ ID NO: 1 or 2.
3. The antibody of claim 2 wherein the epitope is in an EGF-like domain.
4. The antibody of claim 2 wherein the epitope is in a cys-rich domain.
5. The antibody of claim 2 which is selected from the group consisting of A6C12.11, A6F8.6, A7H1.19, A8F1.30, A8G3.5, A8H3.1, A8H3.2, A19A10.30, A10B2.18, A27F6.1, A40G12.8, A2D3.23, A7A10.29, A9G9.9, A15C12.10, A15E4.14, A17A2.16, A17C12.28, A17G12.1, A17H6.1, A18B3.11, A19E2.7, B3F6.17, and B6G7.10.
6. The antibody of claim 3 which is selected from the group consisting of A40G12.8, A8H3.1, A27F6.1, B6G7.10, A17G12.1 and A18B3.11.
7. The antibody of claim 4 which is selected from the group consisting of A19A10.30, A8G3.5, A6F8.6 and A6C12.11.
8. An antibody that specifically binds to an epitope comprised in the domain spanning amino acid residues 46-62 of Cripto.
9. The antibody of claim 8 which is A10B2.18 and B3F6.17.
10. An antibody which binds specifically to an epitope selected from the group of epitopes to which antibodies A6C12.11, A6F8.6, A7H1.19, A8F1.30, A8G3.5, A8H3.1, A8H3.2, A19A10.30, A10B2.18, A27F6.1, A40G12.8, A2D3.23, A7A10.29, A9G9.9, A15C12.10, A15E4.14, A17A2.16, A17C12.28, A17G12.1, A17H6.1, A18B3.11, A19E2.7, B3F6.17, and B6G7.10 bind.

11. An antibody which binds specifically to Cripto and is capable of modulating Cripto signaling.

12. The antibody of claim 11 which specifically binds to an epitope in an EGF-like domain of Cripto.

5 13. The antibody of claim 12 which is selected from A40G12.8, A8H3.1 and A27F6.1.

14. The antibody of claim 11 which specifically binds to an epitope in a cys-rich domain of Cripto.

15. The antibody of claim 14 which is A6C12.11.

10 16. The antibody of claim 11 which is selected from the group consisting of A40G12.8, A8H3.1, A27F6.1, and A6C12.11.

17. An antibody which binds specifically to Cripto and is capable of modulating tumor growth.

18. The antibody of claim 17 which specifically binds to an epitope in an EGF-like domain of Cripto.

19. The antibody of claim 17 which specifically binds to an epitope in a cys-rich domain of Cripto.

20. The antibody of claim 17 which is selected from the group consisting of A27F6.1, A8G3.5 and B6G7.10.

20 21. An antibody which binds specifically to Cripto, which is capable of modulating Cripto signaling, and which is capable of modulating tumor growth.

22. The antibody of claim 21 which specifically binds to an epitope in an EGF-like domain of Cripto.

23. The antibody of claim 21 which specifically binds to an epitope in a cys-rich domain of Cripto.

25

24. The antibody of claim 21 which is A27F6.1.

25. An antibody produced by a hybridoma selected from the group consisting of A6F8.6 (ATCC Accession No. PTA-3318), A8G3.5 (ATCC Accession No. PTA-3317), A8H3.1 (ATCC Accession No. PTA-3315), A10B2.18 (ATCC Accession No. PTA-3311), A27F6.1 (ATCC Accession No. PTA-3310), A40G12.8 (ATCC Accession No. PTA-3316), A17G12.1 (ATCC Accession No. PTA-3314), A18B3.11 (ATCC Accession No. PTA-3312), B3F6.17 (ATCC Accession No. PTA-3319), and B6G7.10 (ATCC Accession No. PTA-3313).

26. An antibody which binds specifically to Cripto and is capable of blocking the interaction between Cripto and ALK4.

27. The antibody of claim 26 which specifically binds to an epitope in an EGF-like domain of Cripto.

28. The antibody of claim 26 which specifically binds to an epitope in a cys-rich domain of Cripto.

29. The antibody of claim 26 which is selected from the group consisting of A8G3.5, A6F8.6 and A6C12.11.

30. An antibody which binds specifically to Cripto, which is capable of blocking the interaction between Cripto and ALK4, and which is capable of modulating tumor growth.

31. The antibody of claim 30 which specifically binds to an epitope in an EGF-like domain of Cripto.

32. The antibody of claim 30 which specifically binds to an epitope in a cys-rich domain of Cripto.

33. The antibody of claim 30 which is A8G3.5.

34. A Cripto antibody capable of internalizing Cripto.

35. The antibody of claim 34 wherein the antibody is conjugated to a chemotherapeutic.
36. The antibody of claim 34 which is selected from A27F6.1 and B3F6.17.
37. A composition for administration to a subject having a tumor that expresses
- 5 Cripto comprising at least one of the antibodies of any of claims 1-35.
38. The composition according to claim 37, wherein the subject is human.
39. The composition according to claim 37, further comprising a pharmaceutically acceptable excipient.
40. The composition according to claim 37, wherein the antibody is conjugated
- 10 to a chemotherapeutic.
41. The composition according to claim 37, further comprising a nonconjugated chemotherapeutic.
42. A method of modulating growth of tumor cells *in vitro* in a sample comprising the step of adding to the sample the composition of claim 37.
- 15 43. A method of modulating growth of tumor cells *in vivo* in a subject comprising the step of administering to the subject an effective amount of the composition of claim 37.
44. The method according to claim 43, wherein the subject is human.
45. A method of treating a subject having a tumor that over-expresses Cripto
- 20 comprising administering to said subject the composition of claim 37 in an effective amount.
46. A method of treating a patient having a tumor that over-expresses Cripto comprising administering to said patient the composition of claim 39 in an effective amount.

47. A method of treating a patient having a tumor that over-expresses Cripto comprising administering to said patient the composition of claim 40 in an effective amount.

48. A method of treating a patient having a tumor that over-expresses Cripto
5 comprising administering to said patient the composition of claim 41 in an effective amount.

49. The method according to claim 42, wherein the tumor cell is selected from the group consisting of breast, testicular, colon, lung, ovary, bladder, uterine, cervical, pancreatic, and stomach tumor cells.

10 50. The method according to claim 43, wherein the tumor cell is selected from the group consisting of breast, testicular, colon, lung, ovary, bladder, uterine, cervical, pancreatic, and stomach tumor cells.

51. The method according to claim 44, wherein the tumor cell is selected from the group consisting of breast, testicular, colon, lung, ovary, bladder, uterine, cervical,
15 pancreatic, and stomach tumor cells.

52. The method according to claim 45, wherein the tumor is selected from the group consisting of breast, testicular, colon, lung, ovary, bladder, uterine, cervical, pancreatic, and stomach tumors.

53. The method according to claim 46, wherein the tumor is selected from the
20 group consisting of breast, testicular, colon, lung, ovary, bladder, uterine, cervical, pancreatic, and stomach tumors.

54. The method according to claim 47, wherein the tumor is selected from the group consisting of breast, testicular, colon, lung, ovary, bladder, uterine, cervical, pancreatic, and stomach tumors.

55. The method according to claim 48, wherein the tumor is selected from the group consisting of breast, testicular, colon, lung, ovary, bladder, uterine, cervical, pancreatic, and stomach tumors.

56. A method of determining whether a tissue expresses Cripto, comprising the
5 step of analyzing tissue from the subject in an immunoassay using an antibody of any of claims 1-37.

57. A method of determining whether a cell line overexpresses Cripto, comprising the step of analyzing the cell line in an immunoassay using an antibody of any of claims 1-37.

10 58. The antibody of claim 1 wherein the antibody is monoclonal antibodies.

59. The antibody of claim 1 wherein the antibody is humanized antibodies.

60. The antibody of claim 1 wherein the antibody is human antibodies.

61. A method of treating a subject for a condition associated with undesired cell proliferation, said method comprising administering to said subject the composition
15 of claim 37.

FIGURE 1

Response of the NCCIT, Human Testicular Carcinoma Cell Line, to anti-CFC blocking Cripto mAb A8G3.5

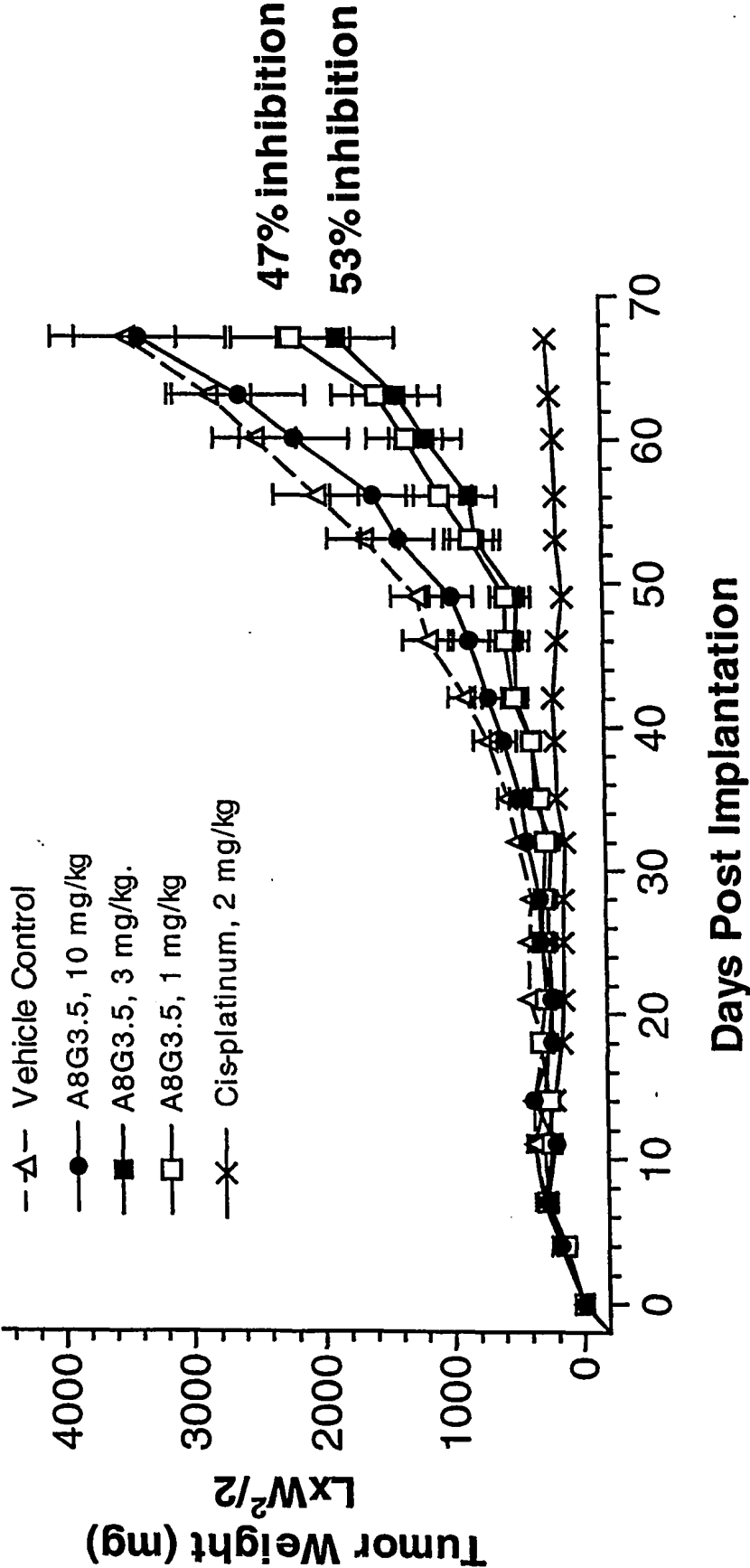


FIGURE 2

**Response of the NCCIT, Human Testicular
Carcinoma Cell Line, to anti-EGF blocking
Cripto mAb A27F6.1**

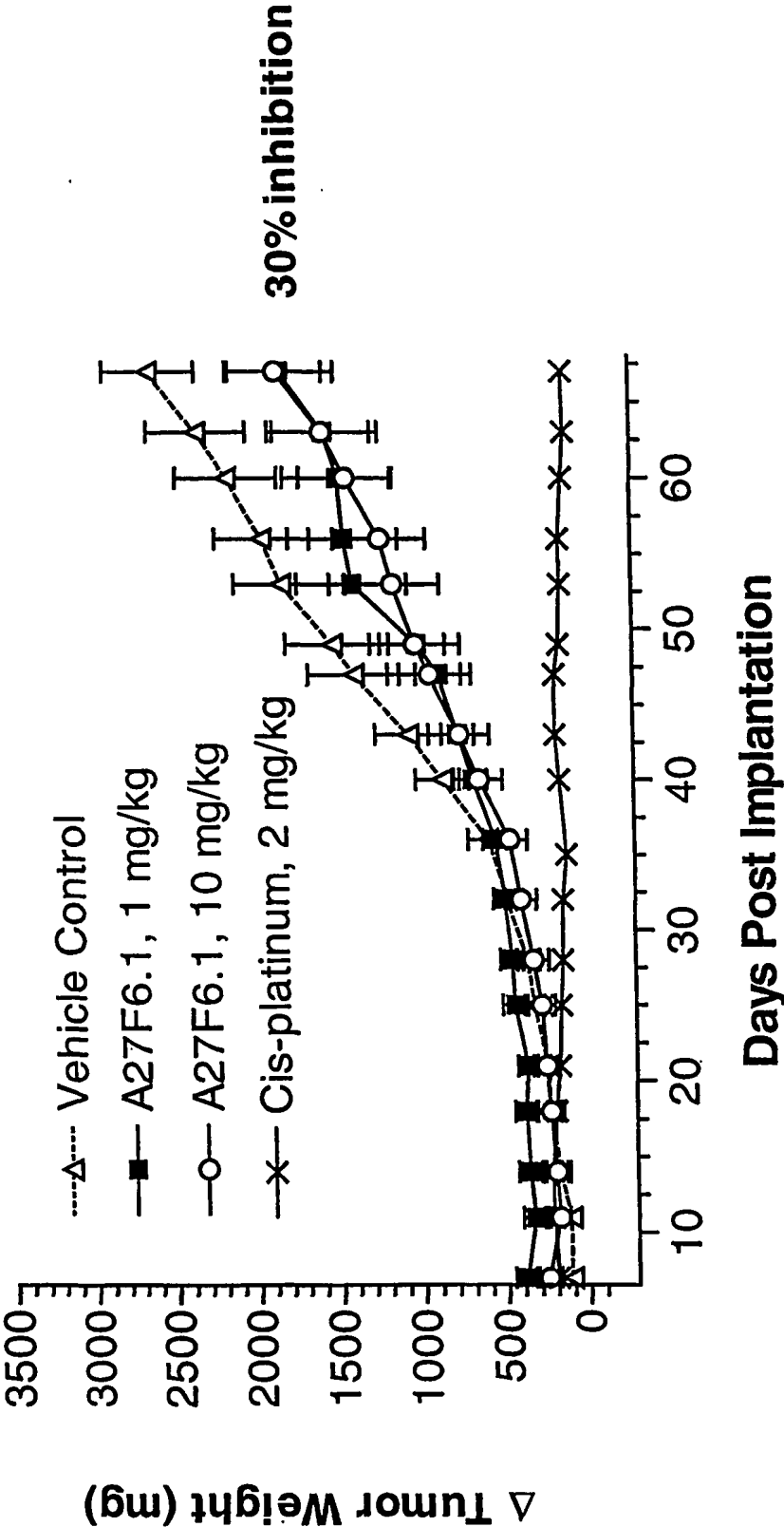
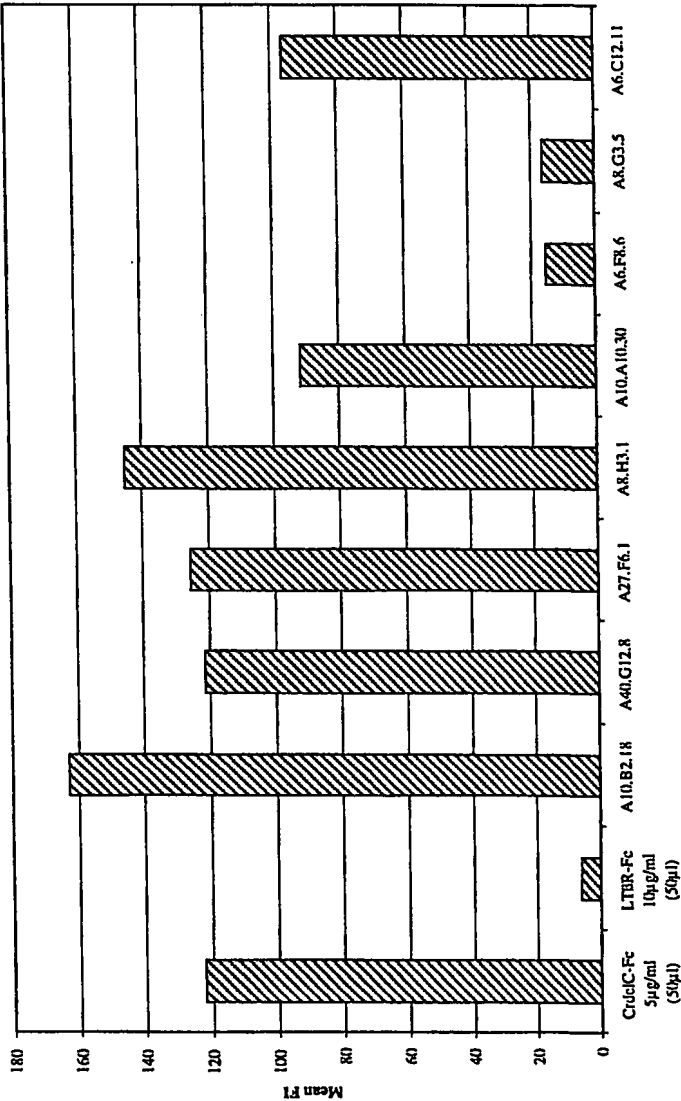


FIGURE 3

FACS: 293/ALK4 cells binding CR-Fc



SEQUENCE LISTING

<110> Biogen, Inc.
 Sanicola-Nadel, Michele
 Williams, Kevin
 Schiffer, Susan
 Rayhorn, Paul

<120> Cripto Blocking Antibodies and Uses
 Thereof

<130> A117 PCT

<140> not assigned yet

<141> 2002-04-16

<150> 60/286,782

<151> 2001-04-26

<150> 60/293,020

<151> 2001-05-17

<150> 60/301,091

<151> 2001-06-26

<150> 60/367,002

<151> 2002-03-22

<160> 2

<170> FastSEQ for Windows Version 4.0

<210> 1

<211> 188

<212> PRT

<213> Homo Sapien

<400> 1

Met	Asp	Cys	Arg	Lys	Met	Ala	Arg	Phe	Ser	Tyr	Ser	Val	Ile	Trp	Ile
1				5					10					15	
Met	Ala	Ile	Ser	Lys	Val	Phe	Glu	Leu	Gly	Leu	Val	Ala	Gly	Leu	Gly
			20					25					30		
His	Gln	Glu	Phe	Ala	Arg	Pro	Ser	Arg	Gly	Tyr	Leu	Ala	Phe	Arg	Asp
		35					40					45			
Asp	Ser	Ile	Trp	Pro	Gln	Glu	Pro	Ala	Ile	Arg	Pro	Arg	Ser	Ser	
	50					55				60					
Gln	Arg	Val	Pro	Pro	Met	Gly	Ile	Gln	His	Ser	Lys	Glu	Leu	Asn	Arg
65					70				75					80	
Thr	Cys	Cys	Leu	Asn	Gly	Gly	Thr	Cys	Met	Leu	Gly	Ser	Phe	Cys	Ala
			85					90						95	

Cys	Pro	Pro	Ser	Phe	Tyr	Gly	Arg	Asn	Cys	Glu	His	Asp	Val	Arg	Lys	
			100					105					110			
Glu	Asn	Cys	Gly	Ser	Val	Pro	His	Asp	Thr	Trp	Leu	Pro	Lys	Lys	Cys	
		115					120					125				
Ser	Leu	Cys	Lys	Cys	Trp	His	Gly	Gln	Leu	Arg	Cys	Phe	Pro	Gln	Ala	
		130				135					140					
Phe	Leu	Pro	Gly	Cys	Asp	Gly	Leu	Val	Met	Asp	Glu	His	Leu	Val	Ala	
145					150					155					160	
Ser	Arg	Thr	Pro	Glu	Leu	Pro	Pro	Ser	Ala	Arg	Thr	Thr	Thr	Phe	Met	
				165					170					175		
Leu	Val	Gly	Ile	Cys	Leu	Ser	Ile	Gln	Ser	Tyr	Tyr					
			180					185								

<210> 2

<211> 188

<212> PRT

<213> Homo Sapien

<400> 2

Met	Asp	Cys	Arg	Lys	Met	Val	Arg	Phe	Ser	Tyr	Ser	Val	Ile	Trp	Ile	
1				5					10					15		
Met	Ala	Ile	Ser	Lys	Ala	Phe	Glu	Leu	Gly	Leu	Val	Ala	Gly	Leu	Gly	
			20					25					30			
His	Gln	Glu	Phe	Ala	Arg	Pro	Ser	Arg	Gly	Asp	Leu	Ala	Phe	Arg	Asp	
		35				40					45					
Asp	Ser	Ile	Trp	Pro	Gln	Glu	Glu	Pro	Ala	Ile	Arg	Pro	Arg	Ser	Ser	
	50				55					60						
Gln	Arg	Val	Leu	Pro	Met	Gly	Ile	Gln	His	Ser	Lys	Glu	Leu	Asn	Arg	
65				70					75					80		
Thr	Cys	Cys	Leu	Asn	Gly	Gly	Thr	Cys	Met	Leu	Glu	Ser	Phe	Cys	Ala	
				85				90						95		
Cys	Pro	Pro	Ser	Phe	Tyr	Gly	Arg	Asn	Cys	Glu	His	Asp	Val	Arg	Lys	
			100					105					110			
Glu	Asn	Cys	Gly	Ser	Val	Pro	His	Asp	Thr	Trp	Leu	Pro	Lys	Lys	Cys	
		115					120					125				
Ser	Leu	Cys	Lys	Cys	Trp	His	Gly	Gln	Leu	Arg	Cys	Phe	Pro	Gln	Ala	
		130				135					140					
Phe	Leu	Pro	Gly	Cys	Asp	Gly	Leu	Val	Met	Asp	Glu	His	Leu	Val	Ala	
145					150					155					160	
Ser	Arg	Thr	Pro	Glu	Leu	Pro	Pro	Ser	Ala	Arg	Thr	Thr	Thr	Phe	Met	
				165					170					175		
Leu	Ala	Gly	Ile	Cys	Leu	Ser	Ile	Gln	Ser	Tyr	Tyr					
			180					185								

Sequence Listing

The 188 amino acid sequence for CR-1 is as follows [SEQ ID NO: 1]:

5 MDCRKMARFSYSVIWIMAIKVFELGLVAGLGHQEFARPSRGYLAFRDDS
 IWPQEEPAPRPRSSQRVPPMGIQHSKELNRTCCLNGGTCMLGSFCACPPS
 FYGRNCEHDVRKENCGSVPHDTWLPKKCSLCKCWHGQLRCFPQAFLPGCD
 GLVMDEHLVASRTPPELPPSARTTTFMLVGICLSIQSY

The 188 amino acid sequence for CR-3 is as follows [SEQ ID NO: 2]:

10 MDCRKMVRFSYSVIWIMAIKAFELGLVAGLGHQEFARPSRGDLAFRDDS
 IWPQEEPAPRPRSSQRVLP MGIQHSKELNRTCCLNGGTCMLESFACACPPSF
 YGRNCEHDVRKENCGSVPHDTWLPKKCSLCKCWHGQLRCFPQAFLPGCDGL
 VMDEHLVASRTPPELPPSARTTTFMLAGICLSIQSY

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
7 November 2002 (07.11.2002)

PCT

(10) International Publication Number
WO 02/088170 A3

- (51) International Patent Classification⁷: **A61K 39/395**, C07K 16/00, 16/18, 16/30, 16/46 (74) Agent: **MANDRAGOURAS, Amy, E.**; Lahive & Cockfield, 28 State Street, Boston, Massachusetts 02109 (US).
- (21) International Application Number: **PCT/US02/11950** (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.
- (22) International Filing Date: 17 April 2002 (17.04.2002)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
60/286,782 26 April 2001 (26.04.2001) US
60/293,020 17 May 2001 (17.05.2001) US
60/301,091 26 June 2001 (26.06.2001) US
60/367,002 22 March 2002 (22.03.2002) US
- (71) Applicant (*for all designated States except US*): **BIO-GEN, INC.** [US/US]; 14 Cambridge Center, Cambridge, MA 02142 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (*for US only*): **SANI-COLA-NADEL, Michele** [US/US]; 4 Maple Road, Winchester, MA 02142 (US). **WILLIAMS, Kevin** [GB/US]; 7 Malden Street, Natick, MA 01760 (US). **SCHIFFER, Susan** [US/US]; 6 Moreland Avenue, Lexington, MA 02421 (US). **RAYHORN, Paul** [US/US]; 48 Mirimichi Road, Foxborough, MA 02035 (US).
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:**
— *with international search report*
- (88) Date of publication of the international search report:
24 December 2003
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: **CRIPTO BLOCKING ANTIBODIES AND USES THEREOF**

(57) Abstract: The invention provides Cripto blocking antibodies, or biologically functional fragments thereof, and uses thereof. Antibodies which bind Cripto and modulate Cripto signaling are provided. Antibodies which bind Cripto and block the interaction between Cripto and ALK4 are provided. Antibodies which bind Cripto and modulate tumor growth are also provided. Antibodies which bind Cripto, modulate signaling, and modulate tumor growth are also provided. Antibodies which bind Cripto, block the interaction between Cripto and ALK4 and modulate tumor growth are provided. The invention also provides methods of using these antibodies in therapeutic, diagnostic, and research applications.

WO 02/088170 A3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/11950

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : A61K 39/395; C07K 16/00, 16/18, 16/30, 16/46

US CL : 424/130.1, 133.1, 134.1, 141.1, 142.1, 178.1, 188.1; 530/387.1, 387.3, 388.1, 388.8, 391.1, 391.7

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 424/130.1, 133.1, 134.1, 141.1, 142.1, 178.1, 188.1; 530/387.1, 387.3, 388.1, 388.8, 391.1, 391.7

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BRANDT et al. Identification and Biological Characterization of an Epidermal Growth Factor-related Protein: Cripto-1. The Journal of Biological Chemistry. 24 June 1994, Vol.269, pages 17320-17328, especially page 17321, second column, lines 8-28.	1-4, 11, 12, 14, 17-19, 21-23, 26-28, 30, 31, 32, 34
Y		37-39, 41, 42-55, 58-61
Y	CICCODICOLA et al. Molecular characterization of a gene of the 'EGF family' expressed in undifferentiated human NTERA2 teratocarcinoma cells. The EMBO Journal. 1989, Vol.8, pages 1987-1991, especially figure 2 on page 1988.	8, 56, 57
Y	EBERT et al. Cripto-1 Induces Phosphatidylinositol 3'-Kinase-dependent Phosphorylation of AKT and Glycogen Synthase Kinase 3Beta in Human Cervical Carcinoma Cells. Cancer Research. 15 September 1999, Vol.59, pages 4502-4505, see entire article.	37-39, 41-55, 61
Y	KANNAN et al. Cripto Enhances the Tyrosin Phosphorylation of She and Activates Mitogen-activated Protein Kinase (MAPK) in Mammary Epithelial Cells. The Journal of Biological Chemistry. 7 February 1997, Vol.272, pages 3330-3335, see entire document.	37-39, 41-55, 61



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

Date of the actual completion of the international search

09 July 2003 (09.07.2003)

Date of mailing of the international search report

05 SEP 2003

Name and mailing address of the ISA/US

Mall Stop PCT, Attn: ISA/US
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Facsimile No. (703)305-3230

Authorized officer

Anthony Caputa

Telephone No. 703-308-0196

INTERNATIONAL SEARCH REPORT

PCT/US02/11950

C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	BIANCO et al. Cripto-1 Indirectly Stimulates the Tyrosine Phosphorylation of erb B-4 through a Novel Receptor. The Journal of Biological Chemistry. 26 March 1999, Vol.274, pages 8624-8629, see entire document.	37-39, 41-55, 61
Y	WO 00/63693 (W.J. KOKOLUS) 26 October 2000, see entire document.	8, 56, 57
Y	US 5,264,557 (SALOMON et al) 23 November 1993, column 3, line 57 to column 5, line 51.	8, 56-60
Y	Database Biosis on STN, Biological Abstracts, Inc., (Columbus, OH, USA), No. 1995:456402, DUBLIN et al, 'Amphiregulin and cripto overexpression in breast cancer: Relationship with prognosis and clinical and molecular variables,' abstract, International Journal of Oncology, 1995, Vol.7, pages 617-622.	8, 56, 57
Y	Database Biosis on STN, Biological Abstracts, Inc., (Columbus, OH, USA), No. 1995:111501, SAEKI et al. 'Expression of cripto-1 in human colorectal adenomas and carcinomas is related to the degree of dysplasia,' abstract, International Journal of Oncology, 1994, Vol.5, pages 445-451.	8, 56, 57
Y	Database Biosis on STN, Biological Abstracts, Inc., (Columbus, OH, USA), No. 1995:110701, SAEKI et al. 'Immunohistochemical detection of cripto-1, amphiregulin and transforming growth factor alpha in human gastric carcinomas and intestinal metaplasias,' abstract, International Journal of Oncology, 1994, Vol.5, pages 215-223.	8, 56, 57
Y	Database Medline on STN, US National Library of Medicine, (Bethesda, MD, USA), No. 94134427, CIARDIELLO et al. 'Inhibition of CRIPTO expression and tumorigenicity in human colon cancer cells by antisense RNA and oligodeoxynucleotides,' abstract, Oncogene, 1994, Vol.9, pages 291-298.	42-55, 61
Y	Database Scisearch on STN, Thomson ISI, (Columbus, OH, USA), No. 93:334632, NORMANNO et al. 'Expression of Amphiregulin, Cripto-1, and Heregulin-Apha in Human Breast-Cancer Cells,' abstract, International Journal of Oncology, 1993, Vol. 2, pages 903-911.	8, 56, 57

INTERNATIONAL SEARCH REPORT

PCT/US02/11950

Continuation of B. FIELDS SEARCHED Item 3:

Medline, Biosis, Scisearch, Cancerlit, Lifesci, Biotechds, Caplus, Pctfull, USpatfull, Europatfull on STN
ATCC on-line